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ABSTRACT

This paper provides background information for setting science education goals. The first part, "History of Reform in Science Education," describes: (1) the National Science Foundation (NSF) curriculum materials and their characteristics in the late 1950s; (2) the milestone studies and the status of science education in the 1970s; and (3) the crisis in science education in the 1980s as described by various reports and the failure of schools to implement NSF curriculum materials. The second part, "Current Goals of Science Education," discusses the relationships of science to society, the common features of exemplary science programs, and four sets of proposed goals of science education. A total of 25 references are listed. (YP)

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Oregon Department of Education
Science Education

Developing Science Education Goals

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Science Curriculum Concept Paper

September 1988

Introduction

Science education goals reflect our educational values but they also organize our reform efforts by providing a vision. Goals go beyond our knowledge to provide 'wisdom' for our activities. This wisdom must come from an understanding of both the history of the science education which precedes our current position and the nature of science education as it currently relates to modern society.

The difficulties of improving and maintaining good science education has led to the view that science education is in a state of crisis (Yager, Bybee, Gallagher, and Renner, 1982). To identify trends and develop a perspective on the difficulties of change requires an examination of first the history of reform efforts in science education and secondly an examination of current goals for the field.

History of Reform in Science Education

The 1957 Sputnik Crisis

The launching of Sputnik in 1957 aroused public interest and concern and led to the crash program to reform science education through the National Science Foundation (NSF) 'alphabet soup' science curriculum materials. Several were well-known and widely adopted:

Elementary Science Materials
Elementary Science Study (ESS)
Science Curriculum Improvement Study (SCIS)
Science--A Process Approach (SAPA)

Junior High Materials
Earth Science Curriculum Project (ESCP)
Individualized Science Instructional System (ISIS)
Interaction Science Curriculum Project (ISCP)
Intermediate Science Curriculum Study (ISCS)
Introductory Physical Science (IPS)

High School Materials
Biological Sciences Curriculum Study, yellow, blue, green versions (BSCS)
Chemical Bond Approach (CBA)
Chemical Education Materials Study (CHEM Study)
Harvard Project Physics (HPP)
Physical Science Study Committee (PSSC)

The NSF curriculum materials were developed by teams of scientists, educators, psychologists, and teachers rather than by one or two authors as in traditional methods of textbook production. The materials attempted to incorporate more of the processes of scientific inquiry and the structure of the disciplines than did textbooks. The objective was to organize the mass of disconnected facts and generalizations which had been presented almost entirely as textbook descriptions requiring rote memorization. There was a corresponding emphasis on student activity in the laboratory as experimental activity rather than laboratory activity as simple exercises of verification (Hofstein and Yager, 1982; Kyle, 1982; Kyle, Shymansky, and Alport, 1982; Petersen, Bowyer, Butts, and Bybee, 1984; Shymansky, Kyle, and Alport, 1982).

The 1970's

There were indications of apparent success in the science education reform efforts of the 1960's:

- A surplus of scientists existed.
- The United States had apparently surpassed the

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Russians in space by landing on the moon.

- The primary reform objectives had been met.
- Many new curriculum materials were completed and widely available.

However, the early to mid-1970's marked the beginning of a realization that science education faced new problems stemming from public reaction to the reforms. By the mid-1970's a significant number of citizens felt that continued support for curriculum materials development was misdirected and even in error. Funds were cut off from NSF in 1976 and a second crisis in science education was underway. Several new developments followed:

- A new NSF program to support science education was created.
- NSF funded three, large status studies:
  - —The Helgeson, Blosser, and Howe (1978) literature survey studied the impact of efforts in curriculum development, teacher education instruction, and science education needs.
  - —The Stake and Easely (1978) case studies described the conditions of K-12 science classroom activities.
  - —The Weiss (1978) demographic survey estimated curriculum materials usage, course offerings, enrollments, and classroom practices.
- *The Third Assessment of Science* by the National Assessment of Educational Progress (NAEP, 1978) examined science knowledge, attitudes and experiences of precollege students up to 1977.
- NSF (1980) solicited analysis of the three status studies from nine major professional organizations in science and science education to analyze the needs of science education.
- Harms and NSTA leaders organized *Project Synthesis* (Harms and Yager, 1981) to synthesize views of the "Desired State" and the "Existing State" in science education.

From these milestone studies emerged conditions of science education at the end of the 1970's which were directly contrary to goals established in the 1960's (Kyle, 1982).

- Ninety percent of the science teachers emphasized goals for science education which were directed towards preparing students for the next academic level and formal study of science.
- Ninety percent of science teachers used textbooks 95% of the time.
- There was no evidence of science being learned by direct experience.
- Nearly all science teachers presented science via lectures and/or question-and-answer techniques based on information existing in the textbook.
- Over 90% of the science teachers viewed their goals for teaching in connection with specific content and had goals which were static givens (Yager, 1983).

The 1980's

By 1980, the research consensus was that a crisis in science education clearly existed. By 1983 a wave of educational reform reports, some sponsored by the federal government, generated surprising interest, support, and funds for the improvement of education to stem "the rising tide of mediocrity." A second wave of reports probed deeper into needed reforms and generally reached agreement:

- Teaching should become a profession.
- Students should be better prepared for a changing society.
- Education policy must enable learning to occur by improving the conditions for learning and teaching.
- Other things--attitudes, climate, relationships, community support--are as important as money.
- Real reform is local, because the act of learning is an individual act.
- More collaboration is needed.

- Education must address the needs of minorities.
- There is a better sense of what must be accomplished to improve education (Green, 1987).

In *A Place Called School* (1983) John Goodlad clearly documented the failure of students to develop any of the abilities commonly listed under 'intellectual development', i.e. the ability to think rationally and to investigate. Researchers meanwhile had developed techniques of meta-analysis (a statistical synthesis of all empirical studies in an area) to answer key questions regarding comparisons of traditional science education textbook approaches with inquiry oriented approaches.

These studies, such as the Shymansky, Kyle, and Alport meta-analysis (1982), clearly established that the average student using the NSF curriculum materials of the 1960's outperformed 63% of the students in traditional textbook courses. These results remained consistent across many studies. On specific measures compared to students taking traditional textbook courses, the average inquiry student's percentile rank was:

- 14 percentile points above the median in achievement.
- 14 percentile above in attitude.
- 15 percentile above in process skills.
- 10 percentile above in analytic skills.
- 10 percentile above in related skills.
- 13 percentile above in creativity/spatial relations.

The NSF curriculum materials placed effective tools at the disposal of teachers but were quickly discarded or not used at all. Why were the NSF programs so poorly implemented and so quickly discarded in favor of the 'back to the basics' movement? That question remains unanswered, and we are left with a current crisis more severe than the crisis of 1957 because of the failure of past reform. Current science teaching is marked by the almost total reliance on textbooks with presentations of science as fundamental knowledge and active investigations reserved for students only at the higher levels if even then (Koballa, 1986).

Current Goals of Science Education

Relationships to Society

In its relationship to the larger society it serves, Kyle points out that science education must be integrated into a larger whole and recognize several important values:

- Science must serve the needs of all students and not just the 3% who will make science a career.
- Science must be part of an overall educational logistic delivery system which supports science education with materials, labs, and administrative support.
- Science education must be supported with an active in-service program.
- Science education must be part of an on-going effort and not a one-time effort to upgrade and adjust the program as part of a logical development.
- Science education must be supported by an on-going, comprehensive in-service program.
- Science education must relate to the issues of a complex, technological society and not restrict itself to possession of information.
- Science education must relate to the active, thinking, problem-solving capabilities of students as well as their capabilities of knowing (Kyle, 1986).

An additional value is made increasingly important by the findings of cognitive science which show students construct their view of science and often produce naive conceptions signficantly different from valid conceptions (Linn, 1986):

- Science education must take a cognitive approach and not just a behavioral or performance oriented one.

Exemplary Programs

Penick and Yager (1983) found exemplary science programs are excellent by design and have several features in common:

- Science is taught and emphasized.
- Textbooks are only secondary to a locally developed or modified curriculum.
- Considerable time is spent developing the curriculum and learning activities in team efforts.
- Administrative support and encouragement stimulates active involvement of faculty.
- Outside consultants and resource people are involved.
- Teachers are heavily involved in staff development.
- The programs emphasize active student involvement in inquiry and decision-making.
- Teachers are enthusiastic and claim ownership of the program.
- The old NSF curriculum materials are often clearly present.
- Societal issues are often a focus of study with activities extending into the community (Penick and Johnson, 1983; Penick and Yager, 1983).

Setting Goals

The National Science Teachers Association has pushed for a new thrust in science education to emphasize goals which relate science to society and technology:

1. The needs for science education are related to current social problems rooted in science and technology, e.g., depletion of energy sources, fear of nuclear energy, genetic engineering.
2. There is an urgent need to recognize societal problems. The knowledge that should be considered important is that which is useful and relevant to the solution of social problems.
3. Science and technology are considered to be a means for improving society. Science education, therefore, should be preparing the future citizens.
4. Science and science education must be oriented to the future in light of its potential impact in helping to resolve societal problems and concerns.
5. Science education must focus not only on cognitive skills, but upon affective, ethical, and aesthetic understandings as well.
6. Today's science is more accurately portrayed as value-laden science in which there are moral and ethical dimensions.
7. Science must be concerned with systematic thinking and emphasize decision-making skills.
8. The goals of science teaching are derived from the interaction of science, technology, and society (Hofstein and Yager, 1982).

Hurd (1972) identified four major purposes of science education:

- Sensitizing students to expect and anticipate change.
- Recognizing that the future of human beings and the quality of life are not capricious.
- Enhancing students' self-concept so that, as individuals, students can use knowledge of science to make decisions that can lead to a more desirable world.
- Helping students to acquire capacities to cope with changes, as well as to shape changes.

Hurd's goals are congruent with those of Simpson and Anderson (1981) who describe their concept of the scientifically literate person:

- Has knowledge of the major concepts, principles, laws, and theories of science and applies them in appropriate ways.
- Uses the processes of science in solving problems, making decisions, and in other suitable ways.
- Understands the nature of science and the scientific enterprise.

- Understands the partnership of science and technology and its interaction with society.
- Has developed science-related skills that enable him or her to function effectively in careers, leisure activities, and other roles.
- Has developed interests that will lead to a richer and more satisfying life and a life that will include science and life-long learning.

The Educational Policies Commission (1962) published a statement concerning values in science education.

- Longing to know and to understand.
- Questioning of all things.
- Search for data and its meaning.
- Demand for verification.
- Respect for logic.
- Consideration of premises.
- Consideration of consequences.

Goals for science education must address areas other than academic preparation. These other areas include the personal needs of students in using science to improve their daily lives in a technological society to address societal problems and issues and to define career education. Goals must move instruction away from textbook-bound approaches to active involvement of students with materials in community settings.

Goals should be generalized in the area of problem-solving to seek interdisciplinary relationships. The problems of value raised by the technological applications of scientific knowledge must be addressed directly. All are necessary to produce scientific literate citizens who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision making (Koballa, 1986; NSTA, 1983).

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